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Blackspot Canker

By W. H. Lawrence.

1904

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CONTENTS.

SUMMARY AND CONCLUSIONS.

Blackspot Canker

By W. H. LAWRENCE.

INTRODUCTION.

Among the diseases of the apple tree in this State, **Blackspot Canker** is one of great economic importance throughout the sections in which it occurs. Being a disease primarily of the bark of the trunk and limbs of the tree, and one that threatens the life of the same, its spread causes considerable alarm. During the past few years it has become so prevalent and descructive in many sections that it is well known even to the casual observer. A few apple raisers have given up in despair, thinking that the disease is one that cannot be controlled. Unfortunately until recently little experimental work has been done to find the best preventive and the proper dates on which to apply it.

During the summer of 1902 the writer began a field study of the **Blackspot Canker.** This study was continued for a period of sixteen months, when it was discontinued on account of the closing of the station where the investigations were carried on. The time spent in this work was rather short, but the results, we believe, are of sufficient value to merit being given in detail. It is the aim of the bulletin to give a complete account of the disease as known and a detailed account of the experimental work done.

HISTORICAL ACCOUNT.

As a subject of publication **Blackspot Canker** is comparatively recent. Ten or twelve years have passed since it became a source of inquiry by the apple raiser. During 1893-4 numerous inquiries were received by the State Board of Horticulture. (1) The disease being a new one and the cause

(1) Second Biennial Rept. Sta. Board Hort., Wash. 21, 29, 69, 1893-4.

and remedy unknown, the matter was communicated to the Div. of Veg. and Path. of the U. S. Dept. of Agr. Through the efforts of the Board Newton B. Pierce was detailed as a special agent to investigate the trouble. Pierce made a trip of general observation through the several sections where the disease was most prevalent. (See above-mentioned report.) Later a similar study was made in Oregon. (2) In 1899 Paddock (3) referred to the disease as the Pacific Coast apple tree canker. Specimens of the disease were sent to Mr. Paddock by horticultural secretaries in Oregon, Washington and British Columbia. On comparing the canker with a similar one native in New York he found it to be entirely different. Specimens were submitted to Prof. C. H. Peck. Peck pronounced the fungus present as a new species of Macrophoma.

Under date of January, 1900, A. B. Cordley (4) published a preliminary report on the disease, gave it the common name of apple tree Anthracnose, and described the fungus present as Gloeosporium malicorticis. During the same month Peck (5) described a fungus in cankered bark under the name of Macrophoma curvispora, collected in British Columbia by R. M. Palmer. In March of the same year C. V. Piper (6) published an account of the disease as known. The following July Cordley's article (7), "Some Observations on Apple Tree Anthracnose," appeared. A late report of the Oregon (8) State Board of Horticulture gives the results of spraying experiments in two apple orchards. Piper (9) in a recent bulletin gives a short account of the fungus and suggests how to control it. Other than these articles mentioned numberous references have been made to the disease. Such references have been brief and usually inaccurate.

CAUSE OF THE DISEASE.

Numerous theories have been offered in explanation for the occurrence of the disease. Nearly all these theories have

(2) Third Biennial Rept. Sta. Board Hort., Oregon, p. 11e, 1895.
(3) Bull. N. Y. State Agr. Exp. Sta. 163, pps. 203-204 D. 1899.
(4) Bull. Oregon Agr. Exp. Sta. 60, Ja., 1900.
(5) Macrophoma curvispora, Bull. Torrey Bot. Club, Vol. 5721, 1900.
(6) The Ranch Blackspot or Apple Canker, p. 10, 8 Mr., 1900.
(7) Some observations on Apple Tree Anthracnose, Bot. Gaz. 48, Jl. 1900.
(8) Sevehth Biennial Rept. Oregon Board of Hort., p. 46, 1902.
(9) U. S. Dept. Agr., Farmers' Bulletin 153, pp. 31-33, 1902.

been abandoned. One which has been recently promulgated is the sour sap theory. This holds that the trees have been feeding on an excess of nitrates; that nitrates collect in the bark of the tree; that fermentation takes place and puts the bark in such a condition that the fungus is able to penetrate it. Such a theory is easily refuted by testing the bark for nitrates. Such tests have been made of infested bark in all stages and of healthy bark, and in neither case have nitrates been found.

It has been known and definitely proven for a period of several years that the canker is caused by a parasitic fungus. According to Minto (1), Pierce as early as June, 1895, grew the fungus from diseased bark collected at Olympia, Washington, inoculated healthy trees in the Sacramento Valley, California, with the fungus and obtained the typical cankers. During the winter of 1900, D. A. Brodie produced the disease on apple twigs placed in water in the laboratory by inoculating them with bits of diseased bark collected in the field. Cordley (2) germinated the spores of the fungus in artificial cultures. Later, when the mycelium was developed far enough to be seen by the naked eye the fungus was transferred to tube cultures. Later inoculations were made in apple twigs with the fungus. The fungus attacked the bark and caused small cankers, showing definitely that the fungus is the cause of the disease. Prof. C. V. Piper has done considerable work on the fungus and has reached similar results. All of the above work has been successfully duplicated by the writer and some additional work has been done on the life history of the fungus.

PLANTS INFESTED BY THE FUNGUS.

Blackspot canker has not been found on other than the cultivated apple. As the disease is apparently limited to the region of the Pacific Northwest it is undoubtedly native on some wild host. Search has been made for such a host, but none has yet been found. Similar canker diseases are found on the alder, cherry, pear, plum, prune and willow. None of these as yet have been proven to be caused by the same fungus as the **blackspot canker.** Those on the cherry, pear, plum

(1) Fifth Biennial Rept. Board Hort., Oregon, p. 42, 1899.
(2) Bull. Oregon Agr. Exp. Sta., 60, Ja., 1900.

and prune probably have the same origin as the one on the apple, as indicated by artificial inoculations discussed later.

SUSCEPTIBILITY OF VARIETIES OF THE HOST.

The disease apparently attacks all varieties of the apple. Some of them are more frequently attacked than others. Such varieties as the Baldwin, Blue Pearmain, Gravenstein, Newton Pippin, Wagner, Wealthy, and Yellow Bellflower are among this number. A few of the varieties that show a somewhat less tendency to disease are the Hubbardson's Nonesuch, Imperial Pippin, King of Tompkins County, Maiden Blush, Olympic, Red Astrachan, Rhode Island Greening, Spitzenburg, Striped Astrachan, Twenty-ounce Pippin and Yellow Transparent. Other varieties, as the Northern Spy, Waxen and Ben Davis, are comparatively free from the disease.

Although some varieties show a greater tendency to disease than others, there also is a great difference sometimes shown in the susceptibility of a certain variety in different localities under nearly the same conditions. In one orchard such a variety as the Baldwin, Gravenstein, Wagner, or Wealthy is oftentimes so badly overcome by the disease that it is no longer a source of profit; other varieties that as a rule are badly diseased may be nearly free from it. In other orchards the reverse is true—the above-mentioned varieties may be nearly free from the disease. It is also true that the individual trees in one row of trees of a single variety sometimes show a marked difference in susceptibility. Some individual trees will become badly infested and die in a very short time, while others will become little diseased. Because varieties are sometimes badly infested in one orchard and comparatively free in an adjacent one some orchardists are of the opinion that the soil upon which the trees are growing has much to do with their resistance to the disease. A study of the Baldwin apple on light sand, sandy clay loam, valley clay, shot clay, black loam and humus revealed that the variety is badly infested in some orchards on all of them.

Poor cultivation is occasionally offered as an explanation for the occurrence of the disease in great abundance in some orchards. Neglected orchards are as a rule more or less infested with fungus diseases and insect pests. Some orchards

seeded to grass and cropped each year are badly infested; other orchards receiving the same treatment are more or less free from it. Well cultivated orchards may or may not, in whole or in part, be badly infested. No general laws can be given with regard to the susceptibility of varieties. Observations on susceptibility were made in Chehalis, Clallam, Cowlitz, Clarke, Jefferson, King, Kitsap, Lewis, Pacific, Pierce, San Juan and Thurston counties.

INJURY.

The injury done cannot be estimated because of the nature of the disease. One to hundreds of cankers, varying in length from 1-4 to 6 inches, or even longer, may be found on a single tree. One or more cankers on the trunk of a tree may girdle it in the course of a single season. Branches may be killed in the same manner. Some trees may be literally plastered with cankers and still continue to produce a partial crop of fruit. Usually when the cankers are numerous the tree soon becomes too weak to bear sufficient fruit to make it a source of profit. Many orchards are ruined in the course of a few years. Young trees suffer greater injury than older ones. Trees, the bark of which has well developed corky tissue, are immune from the disease.

GEOGRAPHICAL DISTRIBUTION.

Blackspot canker is found only in the states of Oregon, Idaho and Washington, and in the western part of British Columbia. According to R. M. Palmer (1) this disease, which he calls "dead spot" or "canker," is found throughout the coast region of British Columbia, being particularly abundant in the Maple Ridge and Mission districts. The disease is also prevalent in Western Oregon and Western Washington, in localities where the rainfall is considerable during the latter part of autumn and early winter. Within the past two or three years it has been collected by Prof. L. F. Henderson of the University of Idaho in the vicinity of Moscow, Idaho.

Similar canker diseases have been collected on the apple in the Walla Walla and Yakima Valleys and in the Palouse country (Wash.). Up to this time none of the cankers exam-

(1) Rep. Insp. Fruit Pests British Colum., pps. 313-315, 1901.

ined have been sufficiently developed so that it was possible to determine their identity. The New York apple tree canker is also found in the state and has a wider range of distribution than the **Blackspot canker.** It is probable that these last mentioned cankers will prove to be of the New York apple tree canker.

DISTRIBUTION OF SPORES.

The only known method by which the disease spreads is by its spore forms. Distribution of spores takes place from July to February. During the summer of 1902 a few mature spores were collected as early as the 7th of July. From this date until the middle of September it was not uncommon to find pustules (acervuli) containing spores that would germinate in water. The greater number of the spores (conidia) are distributed from October to late December or a little later. It is the spores that are set free at this time that do the greater amount of damage in spreading the disease.

Distribution of the spores takes place much more rapidly during a period when moisture is abundant. The spores are surrounded by a substance which when sufficient moisture is present becomes gelatinous and increases in bulk. This substance dissolves readily in water and the spores are set free. They may be washed away or carried by the wind or other agents to parts of the same or other trees.

Several cankers with well developed pustules were moistened with water and placed in a damp chamber. After several hours each acervulus became covered with a mass of jelly like substance containing the spores. More water was added until the gelatinous substance was all dissolved. Because of the numerous spores the water became milky white. The cankers were then placed on a board in a strong current of wind. The water evaporated slowly. When it had all evaporated examinations were made for spores but nearly all had been carried away by the wind. Of the agents of distribution wind is undoubtedly the most important.

INFECTION OF THE HOST.

The fungus enters the bark in several ways. Contact inoculations showed that the fungus is able to penetrate the

smooth uninjured epidermis of young branches and twigs. Similar experiments showed that the fungus also enters through the lenticels in the bark and various mechanical injuries done the host in tending the trees. The more common mode is for the fungus to enter through the lenticels.

PARTS OF THE HOST ATTACKED.

The Blackspot canker fungus, like the bitter rot fungus, causes a disease of both the tree and fruit. It differs from the bitter rot, however, in that the canker stage does by far the greater amount of injury. The apple rot, which to the writer's knowledge has not heretofore been described, is described in this bulletin under the name of Blackspot apple rot. Besides the fruit the bark and the sap wood beneath are also infested by the fungus. The growth of the fungus in the bark varies considerably. As a rule the disease first makes its appearance on the trunks of young trees. In some cases the disease soon involves areas on both trunk and limbs; in others it does not attack the upper portions. As the trees grow older and considerably corky tissue is developed in the bark, the bark becomes resistant to the disease. Because of this it is not uncommon to see old trees with only the younger limbs infested.

GENERAL DESCRIPTION OF THE CANKER.

The time that new cankers make their appearance during a single season varies considerably with the seasons. Very rarely new ones start during July and August. Their appearance at this time is exceptional and ocurs only when weather conditions are favorable. They are few in numbers and never developed enough to be of economic importance. The first cankers that appear in the fall are usually found about the first week of November on the tender twigs of one and two years growth. Others appear on the trunk and large limbs later in the season. The cankers that do the damage appear from early in November to early in February. The greater number appear during late November and early December.

When the young cankers have developed enough to be seen by the naked eye they are round, somewhat sunken and dark colored—a color characteristic of the infested areas. The canker increases very slowly in diameter but the fungus pene-

trates through the bark into the sapwood beneath. Having entered the cambium or growing layer between the bark and the sapwood layers it grows rapidly and soon involves a considerable area of it—often many times larger than the outer portion of the canker. With the return of the growing season of the host the cankers increase rapidly and are fully grown by the last af June of a little later. When mature the fungus has involved the overlying epidermus so that the outer portion of the canker is about the same size as the area of infested cambium beneath.

At first all the cankers are circular but later they become oblong in outline and nearly black in color. When the cankers are mature in size the bark becomes dry and brittle and the dead tissues separate from the surrounding living ones leaving a marked fissure. Beyond this fissure the fungus never spreads.

The mature cankers measure one-fourth of an inch to six inches or more in length by one-fourth to five or more inches in width. Very often they appear to be of much larger dimensions, but as a rule the larger ones are the result of two or more cankers merging together.

After the cankers are fully grown the rest of the life of the fungus is spent in maturing the spores. The first indication of the formation of spores is a slight roughening of the epidermis at the center of the canker caused by the developing pustules. Later other pustules appear nearer the margin so that there are, near the close of the season, spores in all stages in a single canker. When the pustules are mature the overlying epidermis has ruptured exposing a creamy white mass which later becomes black. This mass is composed of hundreds of spores and a substance soluble in water. As the older pustules open first spores are discharged from a single canker for a considerable period of time.

The bark remains on the tree for a time and then drops out leaving a scar.

GENERAL DESCRIPTION OF THE BLACKSPOT APPLE ROT.

In January, 1903, numerous decaying apples were found

among stored fruit. The decaying areas in a few cases were covered with a few pustules. When mature the epidermis of the apple overlying each split open and exposed the central mass of creamy white spores. Microscopic examination showed them to be like the spores of the Blackspot canker fungus except that they were a little longer. Inoculations were made which show that the disease of the tree and of the apple are caused by the same fungus. A description of these experiments is given below.

The source of infection of stored fruit is probably the cankers on the trees. Spores are likely to be found lodged on the fruit as well as on the bark. Later infection of fruit comes from spores developed in decaying fruit. Some of the varieties infected were Stamens Winesap, Baldwin, Northern Spy, Rambo, English Russet, Rhode Island Greening and Yellow Bellflower.

In many cases the decaying areas are found near the basin and cup ends of the apple along with apple scab fungus, in codling moth burrows, and in bruised places but over 50% of the cases observed shows that the fungus entered directly through the epidermis of the fruit.

The first indication of the presence of the fungus is a slight discoloration of the flesh of the apple just beneath the epidermis. The flesh becomes a light brown color and this is marked enough to be seen by the naked eye. As more flesh becomes involved the color becomes a deeper brown or nearly black. The epidermis makes a corresponding change in color. Decaying spots become depressed, dry and leathery. Pustules soon begin to make their appearance at the point of infection. The pustules are usually arranged in concentric circles about the point of infection—the more rapid the rot develops the more regular are these rings of pustules. The pustules when mature split open and expose the creamy white mass of spores.

Moisture and temperature exert a marked influence on the development of the rot. In cool dry weather the spots increase in size but few pustules are developed. During cool, damp weather an abundance of pustules are found. There is also a tendency for some varieties of fruit to decay more rapidly than others.

INSECTS ASSOCIATED WITH BLACKSPOT CANKER.

In some localities where this disease exists, two kinds of insects work in or near the wounds caused by the fugus. One or both may sometimes be found in the same orchard.

The Bronze Apple-tree Weevil (Magdalis aenescens Lev.).—The adult females are small bronze or nearly black beetles with long beaks. About the time the cankers are mature in size these beetles eat holes in the bark near the margins of the cankers. A single egg is deposited in each hole. A few to several hundred of those eggs may be deposited around a single canker. The work of the beetle and of the larvae retard or prevent the growth of a callus.

The Wooly Aphis (Schizoneura lanigera Hausmann).—After the cankers are surrounded by a fissure, split down the center, or the diseased bark has fallen out, the wooly aphis finds its way into the wound. The aphides multiply rapidly and soon involve the entire callular tissues. The action of these insects on the tissues causes them to become abnormal forming a thick knotty callus which does not grow enough to close the wound.

COMMON NAME OF THE DISEASE.

Blackspot canker is known under a number of different names. Canker, Black canker, Blackspot Apple canker, Blackspot, Dead spot Apple tree Anthracnose and Sour Sap disease, are several of the names applied to it. There are several somewhat similar diseases of the apple throughout the United States. Among these are the New York Apple tree canker and the Illinois Apple tree canker. The term canker is a general one that includes nearly all the diseases involving the bark of trees. In order to retain uniformity of names and to retain the name which so acurately describes the canker the author has chosen to use the common name of **Blackspot canker.**

THE NAME AND DESCRIPTION OF BLACKSPOT CANKER FUNGUS.

The fungus has been described by C. H. Peck (1) as

(1) Bull. Torrey Bot. Club, Vol. 27, 21 Ja., 1900.

Macrophoma curvispora and by A. B. Cordley (2) as Gloeosporium malicorticis. Neither of the above descriptions agree closely with the fungus observed in these investigations. The description is as follows:

Parasitic in the bark and sapwood of the trunk and the branches and on the stored fruit of the cultivated apple.

In the Bark.—Infested areas depressed, dark brown to blackish, oblong in outline one-fourth to six inches in length or longer; sometimes merging together when fully grown, free from the sap wood and bounded by a ragged fissure; acervuli (pustules) abundant, irregularly but quite equally distributed; round to oblong 200-900 mmm. in length, averaging 400-700 mmm., rupturing the epidermis, exposing a creamy white mass, later becoming black; pycnidia absent; stroma usually flattened rarely concave, bearing numerous simple or branched, septate conidiophores as long as, or longer than the conidia; conidia borne acropettally, non-septate, hyaline or rarely with a greenish tint, oblong, geniculate or usually curved 3.8-5 mmm. X 15-20 mmm.

On the Fruit.—Decaping spots light to dark brown, concave, dry and leathery; acervuli numerous, usually larger than those in bark, usually concentrically arranged; stroma as described above; conidiophores longer. usually much branched, conidia varying much in size and shape, as long as 30 mmm.

GERMINATION TESTS WITH SPORES.

Germination tests on the 19th and 29th of July, 1901, with spores collected in the field gave negative results. A third trial on August 13th gave positive results. Tests in 1902 were begun on the 9th of July. Spores germinated in 24 hours. Later in the season numerous tests were made with varied results. In some cases nearly all the spores would germinate; in others not a single one would germinate. By the second week in September no difficulty was met with in getting positive results. During 1903 results of germination tests were about the same as the previous year except that spores taken during the third week of May germinated. Similar results were obtained with spores taken from pustules in the bark

(2) Botanical Gaz., Vol. 30, No. 1, p. 57, J. 1, 1900.

of a pear tree—the result of artificial inoculation with Blackspot canker fungus in early spring.

Although spores will germinate at almost any time during the summer when placed in water they seldom cause infection of the host until late in autumn. A moderately low temperature and plenty of moisture are two important factors in germination. Such conditions are present in November and later in winter. Several collections were made of old spores during March and tests made to determine the length of time they will retain their vitality. None of these spores would germinate. Tests were also made with spores taken from dry bark collected in the field during the winter. Not a single spore would germinate. The length of time the spores of this fungus retain their vitality is undoubtedly short.

ARTIFICIAL CULTURES.

Sugar Agar.—Blackspot canker fungus was grown on this culture medium from infested bark. Numerous promiscuously scattered tufts of erect white hyphae grew but no spore forms were produced. Five stab inoculations with this fungus in the trunk of an apple tree gave five cankers, two of which produced spores.

Potato Agar.—Pure cultures of the fungus were obtained by placing pieces of infested bark in culture tubes containing agar with potato as a nutrient. The fungus grew very slowly. Few erect hyphae were produced. Creeping hyphae were quite abundant. The creeping hyphae produced, singly and in groups, numerous small one-celled, linear oblong, oblong, or slightly curved spores varying from 2-11 mmm. usually about 8 mmm. in length. Cultures similar to the above were made on the 29th of July and the 12th of August. Growth of the fungus at first was the same as above. Later pycnidia developed just beneath the surface of the agar, on the agar, and on the sides of the culture tubes. Some of them became brownish black and grew nearly as large as a pin head. Later in the season a few of them discharged a small mass of jelly like substance containing curved hyaline spores like those taken from pustules in the cankered bark of the apple tree. The results of the inoculations made with these spores are given below. Small spores were also found on the creeping

hyphae. They were like those mentioned above but more uniform in size, measuring 5-7.5 mmm. in length. Cultures of the fungus in decaying apples were also obtained. Numerous small spores were produced but no pycnidia developed.

Sterilized Corn Stems.—The fungus grew slowly and produced a few tufts of dingy white hyphae. No spore forms were found.

Sterilized Pumpkin Rind.—The fungus grew rapidly on this medium, became dark colored and produced numerous pycnidia. Only a few curved spores were found in these cultures. They were typical but a little longer than those taken from pustules in cankered bark of the apple tree.

ARTIFICIAL INOCULATIONS.

Stab Inoculations.—On the 19th of December, 1902, three inoculations with spores of the fungus were made in the limb of a cherry tree. Later 44 additional inoculations were made with both spores and mycelium of the fungus. All of these inoculations took effect. The cankers were all rather small but were well marked and like the cankers found in the orchard. Not a single canker produced spores. This experiment shows a probable relationship between the cakners in orchards and those produced by inoculation. In several instances gummosis was caused by the growth of the fungus either at the point of inoculation or some little distance from it.

On the 28th day of February, 1903, 60 inoculations were made in a pear tree with the spores and mycelium from a decaying apple; 59 of these inoculations took effect. Ten were made in the trunk and 50 in the limbs. On the limbs the fungus, in all cases, penetrated through the bark and into the sapwood beneath; on the trunk it did not enter more than half way through the bark. Pustules and mature spores were found in the cankers on the limbs; no pustules or spores were found in the cankers on the trunk. Spores in these pustules germinated during the third week of May. The cankers on the trunk of the pear caused by inoculating it with **Blackspot canker** fungus are identical with cankers found on the trunks of many pear trees in orchards. Spores have not been collected from the last mentioned cankers. The results of the inocula-

tions indicate that the canker of the pear is also caused by the **Blackspot canker** fungus.

Fifteen inoculations were made in plums and prunes. Cankers were produced but no pustules or spore forms were matured.

From the general appearance of these cankers and ones that appear on plum and prune trees in orcherds they are probably caused by this same fungus.

A considerable number of inoculations were made in apple twigs with the fungus grown in pure cultures from both infested apple bark and decaying apples. In nearly all cases these inoculations gave positive results.

Contact Inoculation.—During the last week in December a number of apple twigs were inoculated by placing spores from decaying apples in a drop of water on the surface of the uninjured epidermis. Culutre cells made of glass tubing were then placed over the twigs covering the water and spores. In about four weeks time three well developed cankers were found in the bark enclosed in the cells. Spores were also taken from pycnidia in tube cultures and placed on twigs in the above mentioned cells. A couple of well developed ones were present at the end of six weeks time. Small particles of agar containing the mycelium of the fungus grown from decaying apples and also infested bark were placed on twigs in cells with positive results. Cankers appeared in less than three weeks time.

A large number of apple twigs placed in water and in moist soil were sprayed with water and spores were then placed on them. At the end of seven days 21 cankers were visible to the naked eye. Other cankers appeared in 10 to 21 days.

Apples placed in moist chambers and inoculated by placing spores in drops of water on the uninjured epidermis gave positive results in more than half of the cases tried. Two weeks from the time these spots were visible to the naked eye mature spores were taken from pustules in them.

REMEDIES AND PREVENTIVES.

Splitting the Cankers.—Splitting the small cankers merely

retards the growth of the fungus for a short time by allowing the canker to partially dry out along the incisions.

Cutting Out the Cankers.—Removing the cankered bark is an expensive and laborious method. It is possible to keep the disease in check on small young trees when little diseased by keeping all the cankers cut out. When the trees are large and have hundreds of cankers on them with new ones appearing from November to February it is impossible to keep the disease in check by such a method. In some cases the fungus matures spores in the sapwood even after the infested bark has been removed.

Painting the Trunk and Limbs.—Several mixtures of oils and various other compounds were applied to the trunks of trees to note their effect and to find a substance that would withstand the frequent winter rains and also prevent the fungus from attacking the tree. Copper compounds were used as preventive agents. Crude petroleum and cotton seed oil when mixed together and with one of the copper compounds apparently did not injure the trees and withstood the frequent rains well. Their value as a preventive has not been fully determined. Further trial must be made before they can be recommended.

Some Miscellaneous Spraying Records.—According to A. H. Carson (1) of Grants Pass, Oregon, "Eisman Bros., have an apple orchard of 20 acres six miles west of Grants Pass, found it badly diseased with anthracnose (Blackspot canker.—Ed.). In fact the fungus would in a short time have destroyed the orchard had not the brothers taken hold of the matter determinedly. They bought a gasoline engine and pump and began systematic spraying with Bordeaux mixture as early in the fall as the apples were gathered * * * that they have been rewarded with success is evidenced by the present healthy and luxuriant growth of the orchard. The old dead spots are rapidly healing over, no new growths have appeared * * * This fall Eisman Brothers will spray again with Bordeaux, as they now know spraying will destroy the disease and keep the orchard healthy and free from the fungus * * * William Hellwell of Yoncolla, Douglas county, has a fine 10 acre

(1) Seventh Biennial Rep. Board Hort., Oregon, p. 46, 1902.

orchard that the anthracnose has become well established in. He was very successful in treating the disease by spraying with Bordeaux mixture early last fall." Mr. O. C. White of Olympia, Thurston county, Wash., recently informed the writer that he had had good success in combatting the disease by spraying with Bordeaux early in the fall. Mr. George Meyers of Orcas, San Juan county, Wash., has a commercial orchard of Blue Permain, Gravenstein, Wagner and Yellow Bellflower. Five or six years ago this orchard became infested with **Blackspot canker.** Bordeaux mixture was used as a preventive. During the summer of 1903 not a single canker could be found in the orchard. The spraying was not done at the time recommended in this bulletin but the work was so thoroughly done and the applications frequent enough so that the trees were well protected with Bordeaux during the season that the spores are distributed.

The Resin-Sal Soda-Bordeaux.—This spray was applied during early autumn and did not prove to be as efficient as other sprays used and cannot be recommended.

Resin-Sal Soda-Glue-Copper Carbonate.—This spray forms a good coating on the tree but will not withstand the rains.

Sulphur-Lime-Copper-Sulphate.—An application of this spray was made on the 4th of November. This spray is less efficient than the following sprays:

Bluestone (Copper Sulphate).—During the first week of December 25 young trees were sprayed with a bluestone (1 pound of bluestone to 8 gallons of water). The application was made during wet weather when it was too wet to use other sprays. A considerable number of young cankers had already made their appearance. No new cankers appeared after a few days after the application was made. The disease was greatly reduced from previous years.

Bordeaux-Petroleum Emulsion.—Four badly infested young trees were selected; three were sprayed and one left for a check. Two applications were made; one at the time when the leaves were nearly all off the trees and another two weeks later. The following spring when the cankers were mature two sprayed trees were entirely free from the disease, the third sprayed tree had one canker on the trunk, and the fourth

(check) had eight large cankers on the trunk and larger limbs. At this time the foliage on the sprayed trees was dark green and healthy; the foliage on the check tree (not sprayed) was yellowish and the tree was nearly dead. This mixture withstands the rains well and apparently does not harm the tree. The spray promises to be a good preventive. As but a single trial was made and for one season only, we do not know the effect it might have on the trees at some later date.

Bordeaux Mixture.—Six badly infested trees were sprayed with Bordeaux the third week in December. At the time of application many new cankers were just large enough to be seen with the naked eye. The spraying was done so late in the season that the results were not very satisfactory. Few new cankers appeared after the work was done. The main experiment was carried out in an orchard of ten years old Baldwin trees. Seventy-five trees were sprayed before the young cankers began to grow. A second spraying was done one week later. Ten of the sprayed trees had cankers on them but they were few in number and mostly small. Of an equal number of check trees 25 were infested; four trees died and about 12 were so badly overcome that they made little or no growth during the following season. Bordeaux proves to be a valuable preventive when applied before the fungus attacks the trees in autumn.

THE FORMULA AND PREPARATION OF BORDEAUX.

The formula for double strength Bordeaux mixture is:

Copper Sulphate (Bluestone)	12 pounds.
Quick-lime	8 pounds.
Water	50 gallons.

To prepare the spray 12 pounds of bluestone in 25 gallons of water. Slake eight pounds of lime and add enough more water to bring the mass up to 25 gallons. Stir the lime water thoroughly and then pour the two solutions together in a third vessel. It is best to strain the mixture before applying it, to remove all foreign particles that might clog the nozzle of the spray pump.

Index to Plate 11.

Unless otherwise stated all figures in Plates 11, 12, 13, are magnified about 600 diameters.

Figs. 1-10. Showing variations in size and form of conidia (spores).

Figs. 11-16. Conidia germinated in water.

Figs. 17-19. Branched conidiophores bearing conidia, taken from pustules in bark of apple tree. See also Plate 13, Fig. 69.

Figs. 20-25. Pieces of germ-tubes produced by germinating conidia in water. These germ-tubes are in turn producing micro-conidia.

Figs. 26-33. Showing some variations in size and form of micro-conidia.

Index to Plate 12.

Figs. 34-36. Conidia taken from pustules in the bark of a pear tree and germinated in water. (Mag. about 350 times.) Plate 8, Fig. 11.

Figs. 37-39. Small conidia taken from pustules in the cankered bark of a pear tree and germinated in water.

Figs. 40-51. Conidia taken from pustules in the cankered bark of a pear tree.

Figs. 52-56. Conidia produced in potato-agar tube-cultures on fungus grown from infested apple tree bark. (Mag. about 700 times).

Fig. 57. A conidium germinated in an agar film in a Van Tieghem cell showing the development of two micro-conidia.

Fig. 58. A micro-conidium with vacuoles.

Fig. 59. A group of micro-conidia on the end of a germ-tube from a germ-tube from a germinating spore in a potato-agar culture.

Index to Plate 13.

Figs. 60, 62 and 63. Small conidia on fungus in tube-cultures grown from infested apple bark.

Fig. 61. Micro-conidia on mycelium from a spore in agar in a Van Tieghem cell.

Fig. 64. Micro-conidia in a tube culture on fungus grown from a decaying apple.

Figs. 65-67. Branched conidiophores bearing conidia taken from pustules in a decaying apple.

Fig. 68. Taken from a pycnidium in agar tube-culture. Fungus was grown from canker in the trunk of an apple tree.

Fig. 69. A single conidiophore bearing a single conidium.

Figs. 70-71. Two conidia taken from a pycnidium in a culture of sterilized green apple. The fungus was grown from a decaying apple.

Figs. 72-75. Some variations in form of the mycelium of the fungus as found in cultures.

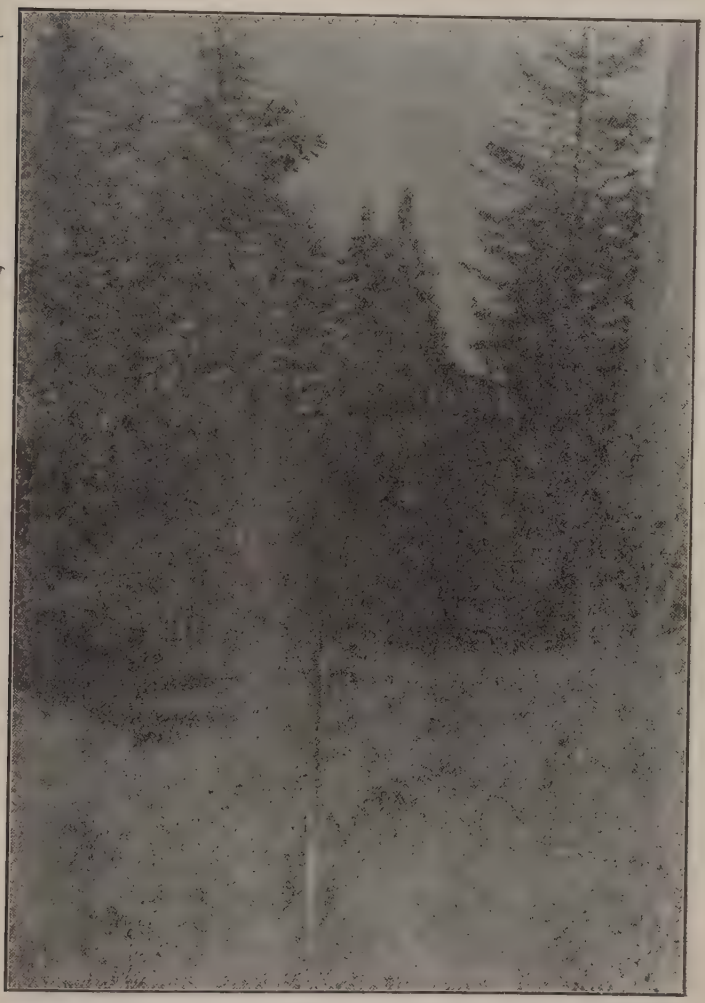

Plate 1, Fig. 1—A young Wealthy tree that has been infested with Blackspot Canker fungus for 3 or 4 years. The bark on one side of the trunk of the tree is dead and has flaked off. One branch is dead and the remainder of the tree is nearly defoliated. Many of the smaller branches are also dead.

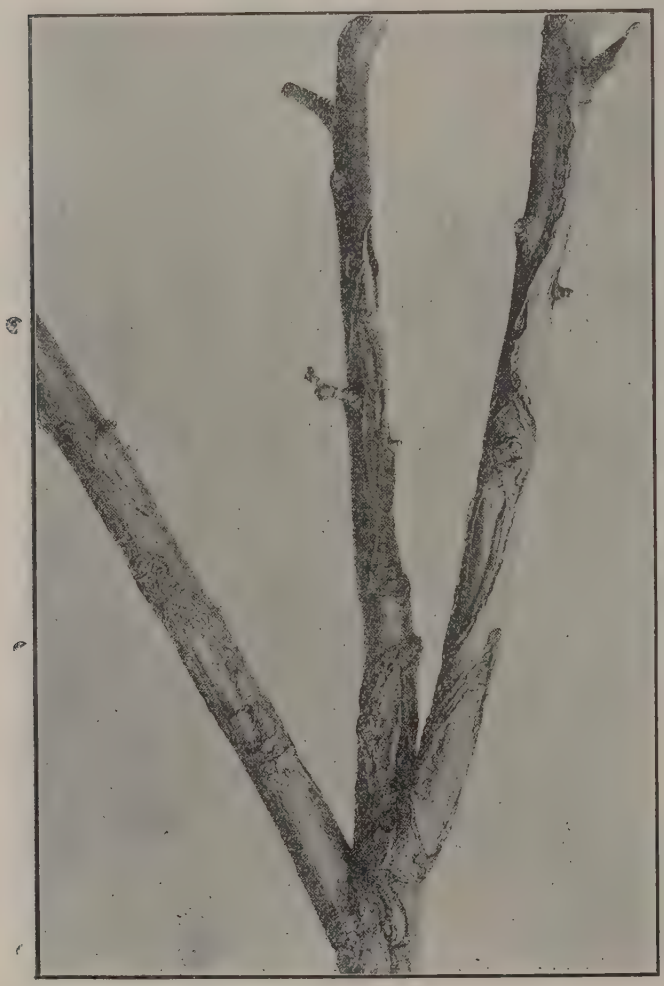

Plate 2, Fig. 2—Three main branches of a young Wealthy tree, showing the action of the fungus The cankers are one and two years old. A portion of the bark in the older cankers has fallen out, leaving the wood exposed.

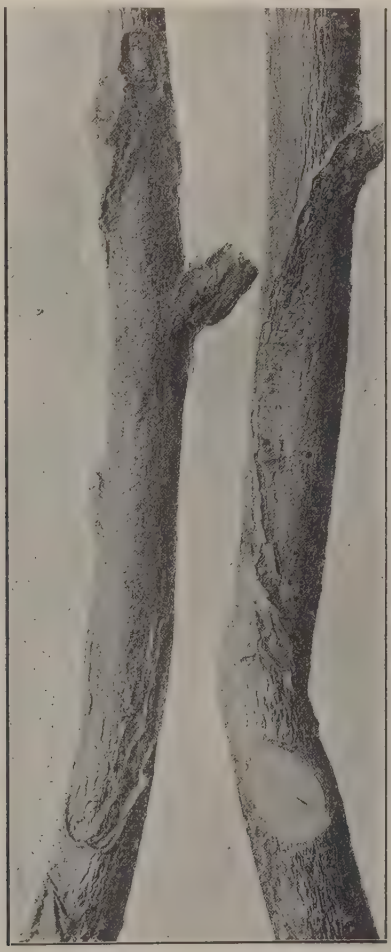

Plate 3, Fig. 3—Portions of two infested branches, showing cankers with well developed pustules. The open pustules appear as dots on the cankers. The cankers are one year old (natural size).

Fig. 4.

Plate 4, Fig. 4—Section of the limb of a tree showing old scars caused by the fungus. (One-half natural size).

Fig. 5.

Fig. 6.

Fig. 5—Section of a cankered branch, showing part of a mature canker with pustules surrounded by a ragged fissure caused by the dead bark separating from the living, adjacent to which are several large holes, the work of the Bronze apple tree weevil. (See page 14).

Fig. 6—A canker in which the woolly aphis has been feeding on the callular tissues causing them to become swollen and conspicuous.

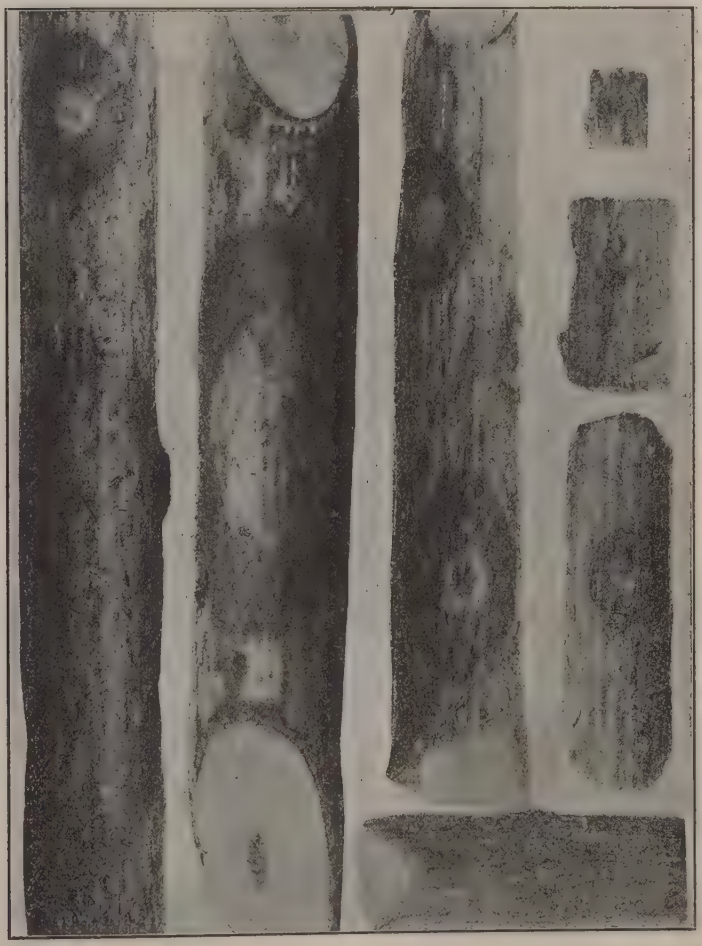

Plate 5, Fig. 7—Sections of apple twigs, showing the size and shape of young cankers when they first begin to grow.

Plate 6, Fig. 8—Blackspot apple-rot. Two apples infested with blackspot canker fungus in stages of decay showing the pustules (acervuli) arranged in concentric circles about the point of infection. There is a sharp line of demarcation between the infested and sound flesh of the fruit. This character is best shown in the upper specimen.

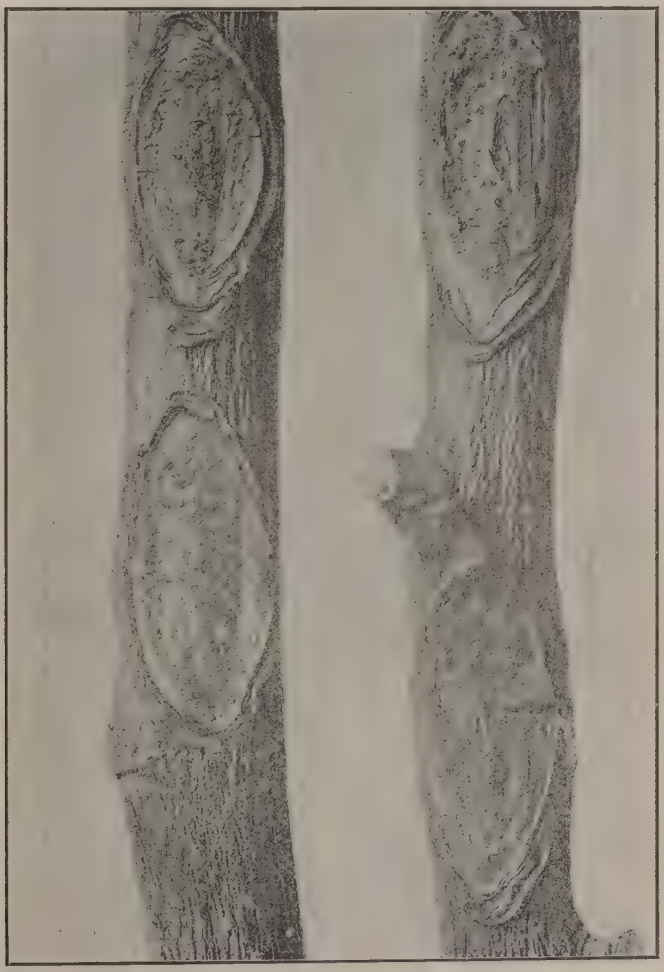

Plate 7, Fig. 9—Cankers on limbs of an apple tree, caused by inoculating the limbs with fungus taken from a decaying apple. The cankers all contain numerous pustules in which mature spores were developed.

Plate 8, Fig. 10—Blackspot canker on the limbs of a pear tree, caused by inoculating the limb of the pear with fungus in decaying apples. The cankers appear somewhat different than on the apple. Pustules with mature spores were developed in these cankers. The epidermis on the cankers usually soon flakes off.

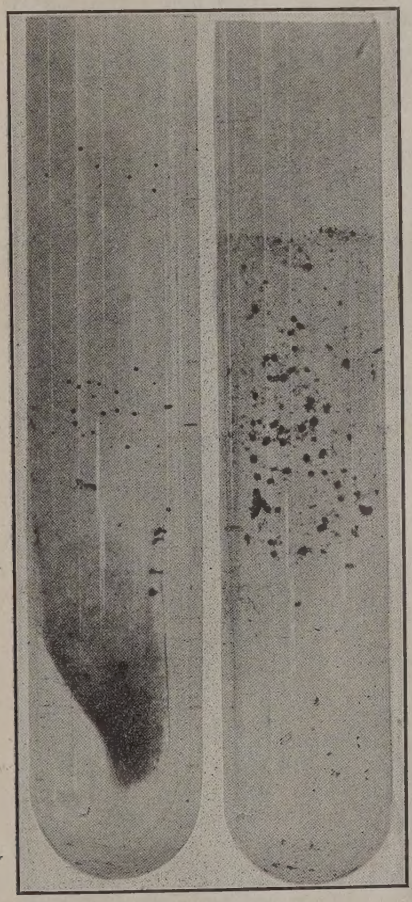

Plate 9, Fig. 11—Two tube cultures containing blackspot canker fungus. Numerous pycinidia are present. Some of these developed spores that were typical of those in nature.

Plates 2-9 from photos taken by Prof. H. S. Davis.

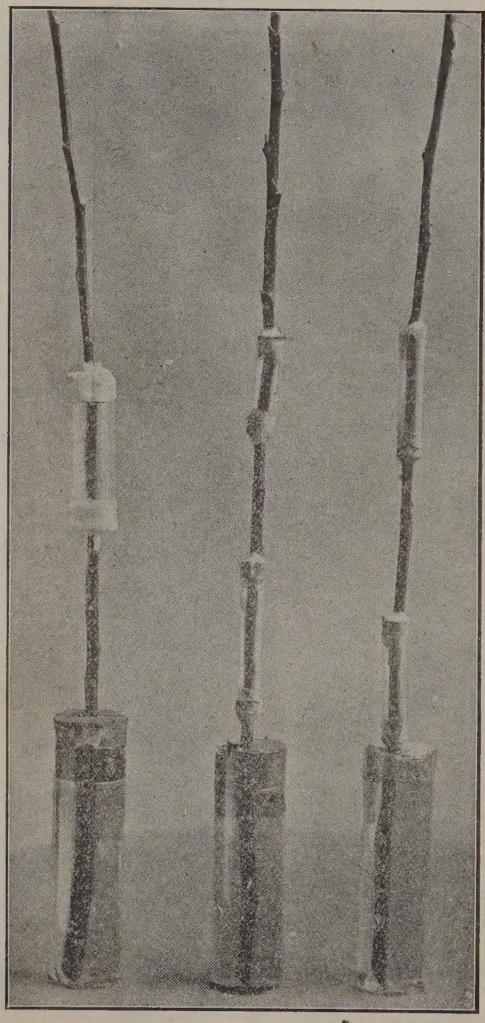

Plate 10, Fig. 12—G. B. Cells—Apple twigs placed in bottles containing water on which were placed sections of glass bottles after putting drops of water on the stems that contained spores of the blackspot canker fungus. This plate shows one of the methods used in determining the shortest length of time it takes the cankers to appear after the spores have found lodgment on the bark.

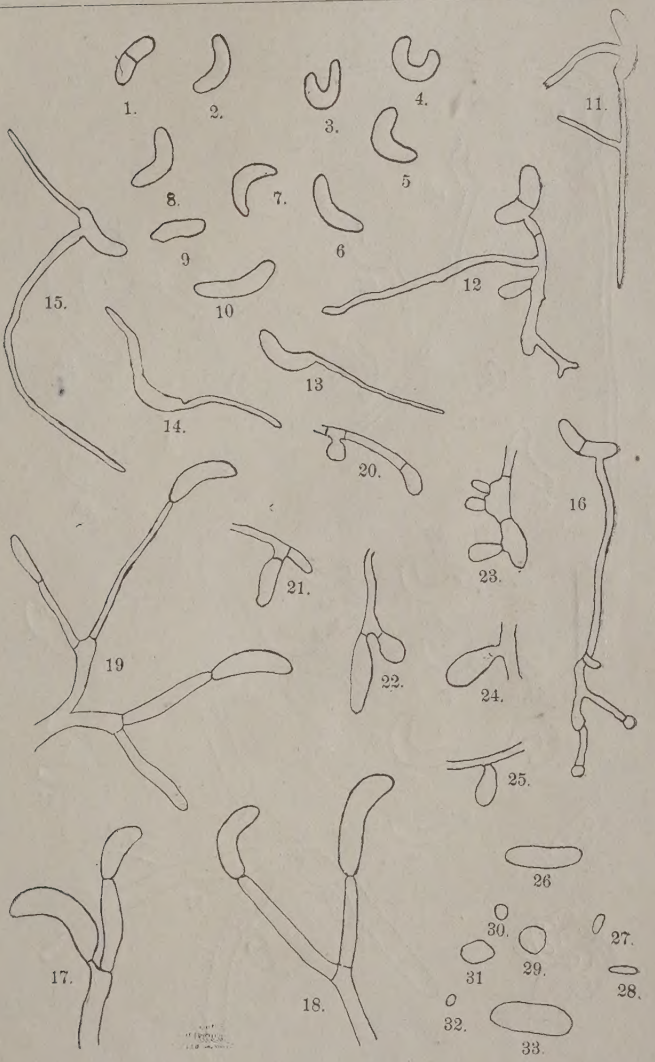
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Plate II.

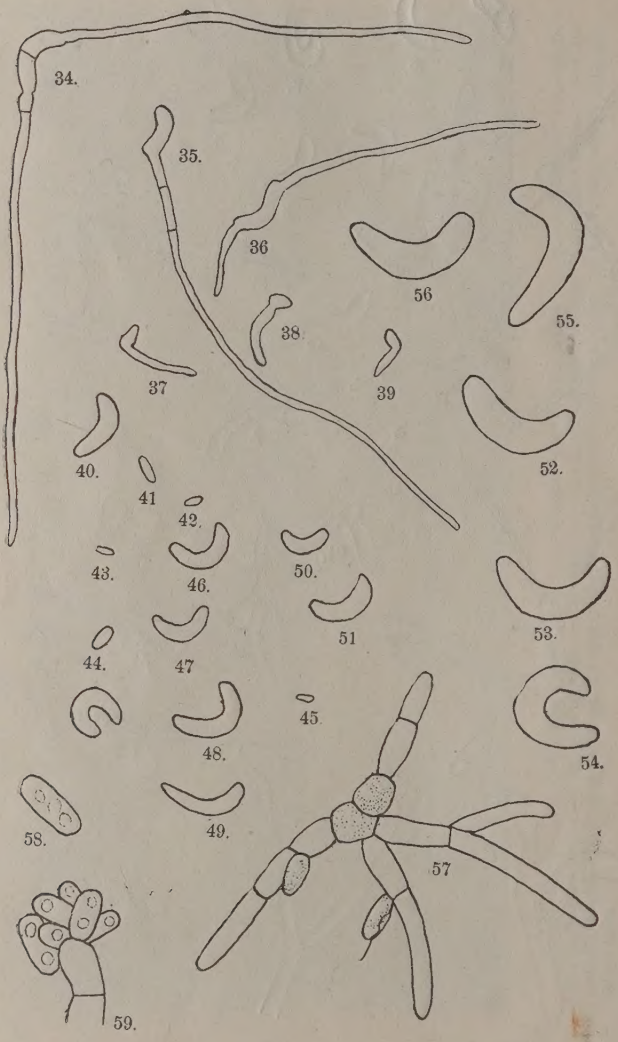
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Plate 12.